Pleodorina, a new genus of the Volvocineæ.[1]

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WITH PLATE XXVII.

In September, 1893, the writer collected at Palo Alto, California, a Volvox-like alga, which Dr. D. H. Campbell at once suggested was different from any described genus. Subsequent review of available literature on the subject at Stanford University and by Dr. W. G. Farlow and Mr. B. M. Davis at Harvard University, brings to light no mention of a similar form. The plant is a so-called "cœnobium" of about 128 biciliate cells, one-half to two-thirds of which are, in the non-sexual form observed, "parthenogonidia." In view of its apparent affinity with *Pandorina* and *Eudorina*, the larger number of cells, and the differentiation of the cells into two kinds, the name *Pleodorina* seemed appropriate and was adopted.

The first specimens were collected Sept. 19, 1893, in an irrigation ditch at Palo Alto, and others were taken from the same place at intervals of a few days for about two weeks. They were kept in a wide bell-jar until Oct. 13th, when they suddenly disappeared before a swarm of insect larvæ. The living specimens from which drawings were made were held in place under the microscope by allowing the cover-glass to press upon them slightly. An attempt was made to determine the time required for the full development of the gonidium-bearing individual from the gonidium by isolating mature plants in watch glasses; but the daughter plants were not healthy, and did not come to maturity.

The typical specimens are those in which the gonidia have reached their full size previous to division. Such individuals are spherical (fig. 1) or more often ellipsoidal, and measure 187–258μ in long diameter;[2] the short diameters of ellipsoidal specimens measure 7–20μ less. With one exception the number of cells in those counted varied from ninety-eight to one hundred and twenty-six; the exception numbered sixty-three

[1] Prepared under the direction of Dr. Douglas Houghton Campbell.

[2] Most of the measurements and also the counts of the cells given here are taken from specimens permanently mounted in 25% glycerine after fixing and staining.

cells. The cells are situated in the periphery of the sphere, of which the gonidia occupy a hemisphere or more and the vegetative cells the remainder. The centers of the two areas thus distinguished coincide with the ends of the long diameter in ellipsoidal specimens. The vegetative cells are about 12μ in diameter, and the gonidia just before division 25–30μ. Each vegetative cell (in young individuals the cells are all alike) is oval, with the smaller, clearer end directed outward and bearing two cilia which project through the gelatinous envelope. In each cell a pyrenoid and a red pigment corpuscle are conspicuous, the latter situated on the surface near the forward or outer end (figs. 5 and 7). The pyrenoid is in the inner end of the cell and appears to lie within the center of the single chromatophore, the edges of which extend forward around the periphery of the cell. Specimens fixed with 1% chromic acid, washed, stained with hæmatoxylin and afterward with alum cochineal, show in each cell a centrally located nucleus with a well defined nucleolus (figs. 7 and 8). Some young specimens fixed with picro-nigrosin show a vacuole in the hyaline forward end of the cell.

A number of specimens were fixed and stained with a view to ascertaining whether any protoplasmic connection exists between the cells. After fixing on the slide with 1% chromic acid, some were stained with safranin, Bismark brown, alum cochineal and haematoxylin. Others were fixed and stained with picro-nigrosin, but in no case did any connecting threads appear. At the time when these observations were being made, the writer met with a specimen of *Volvox minor* Stein, and here the connecting threads between the cells were visible in the living plant under a magnification of only 57 diameters and without the use of any stain. In the young of *Pleodorina* the cells are all of the same size and apparently alike, but in the older ones the gonidial cells become gradually larger, and then more spherical and finally even slightly flattened. The granular cell-contents increase; the pyrenoids increase in number, and the red pigment corpuscle becomes less conspicuous and disappears.

The movement of the plant in the water was followed in the case of a few individuals bearing well developed gonidia. In swimming through the water the vegetative pole is directed forward and the plant revolves to the right (in observed cases) on the axis connecting the vegetative and reproductive poles.

The path is parallel to this axis in upward vertical as well as in horizontal movement.

The division of the gonidia was followed in a number of cases on different days. The first cell division took place about two hours after noon and the daughters escaped from the mother plant eighteen to twenty-four hours afterward. Previous to division the investing membrane of the cell begins to swell up and withdraw from the protoplasm, doing so at first in a zone just back of the point of attachment. This for a time gives the forward end of the cell the form of a beak (fig. 6). The two cilia persist on the gonidium and are active even after the cell has divided several times. The succession of divisions is essentially as in *Eudorina elegans.*[3] The first two divisions are perpendicular to the surface of the whole sphere and to each other (fig. 2, *a–c*). Before the next division takes place the walls already formed become curved and oblique, so that seen from the front the cells overlap slightly (fig. 3, *d*). The next division is anticlinal and somewhat oblique (figs. 2, *d* and 4, *b*). As the division proceeds a plate of cells is formed which becomes concave from the front (fig. 4, *c*); the concavity increases until the plate becomes bowl shaped, and the mouth of the bowl closes to form a hollow sphere of very closely arranged cells before the last division takes place.[4] The cells separate slightly and become rounded; then the last division into about 128 cells occurs and the cells are again closer and flattened by contact. Finally the cells become gradually more and more separated from each other, though fixed in the common envelope.

After the last division takes place the cilia begin to form as outgrowths, two from the outer end of each cell. Thus it is to be borne in mind that the cilia do not arise on that end of each cell which corresponds to the ciliated end of the mother gonidium, but on the opposite end. As the cilia become longer they acquire movement and each daughter plant rotates slowly within the swelled up membrane of the gonidium from which it has developed. The daughter plants escape as spheres of cells which are all alike. One case was observed in which the formation of the cilia began before the young plants had reached the spherical stage. This was in the above mentioned sixty-three-celled plant. In this in-

[3]Goebel, Outlines of Class. and Sp. Morph. of Plants (Eng. Trans.) 37. 1887.

[4]Beyond this point the transition was not actually followed but traced by different stages present in each of two fixed mother plants.

stance the daughter plants, 39 in number, consisted of about 64 cells each (maximum estimate). Usually one or two of the gonidia fail to undergo division, and occasionally there are one or more cells in the reproductive area which do not even increase in size.

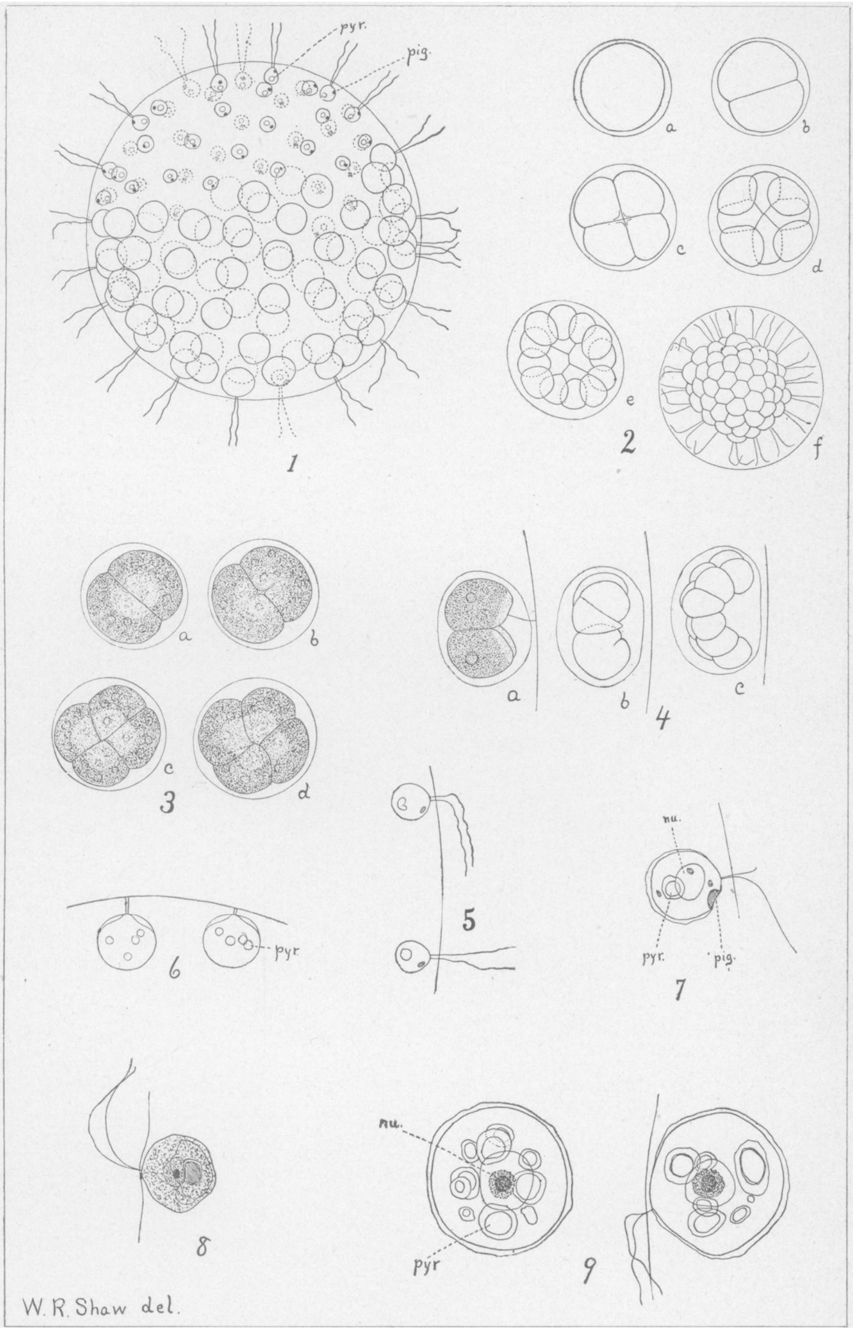
In comparing this plant with others of similar type it is reasonable to suppose that there is a sexual generation yet to be observed.[5] If we consider that *Gonium*, *Pandorina*, *Eudorina*, and *Volvox* represent a near approach to a true line of ascent, we have then in *Pleodorina*, so far as we can judge with no knowledge of its sexual generation, a new member of the series intermediate between the latter two, but much nearer to *Eudorina*. Its close affinity to *Eudorina* is indicated by the absence of any discernible protoplasmic connection between the cells as well as by the mode of development of the individual from ciliated gonidia. It resembles *Volvox* more than *Eudorina* does in the number of cells composing the individual and the specialization of certain cells for the purpose of reproduction. Thus we may expect in the sexual generation a degree of differentiation which shall be a step higher than that of *Eudorina* and nearer to the latter than to that of *Volvox*.

With our present knowledge we may briefly describe the subject of these notes as follows:

PLEODORINA, gen. nov.—Plant body a hollow, spherical or spheroidal "cœnobium" of green biciliate cells fixed in a hyaline gelatinous envelope. Red pigment spot in each cell. No connecting filaments between the cells. Non-sexual reproduction by gonidia; gonidia formed by increase in size of part of the cells; daughters escape from mother plant as spheres of similar biciliate cells. Sexual reproduction not known.

P. Californica, sp. nov.—Number of cells composing the plant body approaching 64 or 128; usually about 120. Plant body about 175–300μ maximum diameter. Cells oval; smaller end hyaline and bearing two cilia which project through the envelope; each cell containing a red pigment spot, nucleus, chromatophore, and pyrenoid. Vegetative cells about 12μ in diameter; cilia several times as long as cells. Non-

[5] Up to date of present writing, April 7, 1894, no more of the plants have been collected.



SHAW on PLEODORINA.

sexual reproduction by development of one-half to two-thirds (50–62%) of the cells into gonidia which retain cilia until ready to divide or longer. Diameter of gonidia 2–3 times that of vegetative cells. Each daughter plant enclosed within the swelled membrane of its mother gonidium until it becomes independent; active before escaping; all cells alike at time of escape. Sexual reproduction not known.

Habitat: Fresh water ditch, Palo Alto, California. Autumn.

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EXPLANATION OF PLATE XXVII.

Fig. 1. Typical plant of 120 cells; from life; cilia diagrammatic and added afterward from fixed specimen; × 178.—Fig. 2. Successive stages of division of gonidium, front view; *a*, 2:50 P. M.; *b*, 3:20 P. M.; *c*, 4:15 P. M.; *d*, 5:05 P. M.; *e*, 5:40 P. M.; *f*, 10:15 following morning; cilia here also diagrammatic; × 337.—Fig. 3. Another gonidium from same mother plant; lighter central area indicates hyaline portion of cell; *d* shows obliquity of dividing walls; *a*, 2:45 P. M.; *b*, 3:25 P. M.; *c*, 3:40 P. M.; *d*, 4:50 P. M.; × 337.—Fig. 4. Side view of another gonidium from same mother plant; *a* shows only one of two cilia which were present in full size and active; *a*, 2:20 P. M; *b*, 3:15 P. M.; *c*, 4:35 P. M.; × 337.—Fig. 5. Two vegetative cells from same plant to show relative size; cilia as in fig. 1; × 337.—Fig. 6. Two gonidia just previous to division, × 337.—Fig. 7. Vegetative cell showing pigment corpuscle; chromic acid 1%, and safranin; permanent mount in glycerine; × 1,000.—Fig. 8. Vegetative cell showing chromatophore surrounding pyrenoid; chromic acid 1%, and hæmatoxylin, afterward stained with alum-cochineal; permanent mount in glycerine; × 1,000.—Fig. 9. Two gonidia showing nucleus and pyrenoids in each cell; same specimen as fig. 8; × 1,000.

All drawings sketched with an Abbé camera; *pyr.* = pyrenoid; *nu.* = nucleus; *pig.* = pigment spot.